

Express Mailing Label No. EV396739010US

PATENT APPLICATION  
Docket No. 7678.815

**UNITED STATES PATENT APPLICATION**

of

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for

**DENTAL CURING DEVICE HAVING  
A HEAT SINK FOR DISSIPATING HEAT**

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# DENTAL CURING DEVICE HAVING A HEAT SINK FOR DISSIPATING HEAT

## BACKGROUND OF THE INVENTION

### 1. The Field of the Invention

[0001] The present invention generally relates to the field of light curing devices incorporating light sources and, more particularly, to the field of heat sinks configured for dissipating heat generated by the light sources of the light curing devices.

### 2. The Relevant Technology

[0002] In the field of dentistry, dental cavities are often filled and/or sealed with photosensitive compounds that are cured when they are exposed to radiant energy, such as visible or ultraviolet light. These compounds, commonly referred to as light-curable compounds, are placed within dental cavity preparations or onto dental surfaces where they are subsequently irradiated by a light-curing dental device.

[0003] Many light-curing devices are configured with a fiber optic wand for directing light from a light source into a patient's mouth. The light source may comprise, for example, a lamp, a halogen bulb or a light-emitting diode (LED). One end of the fiber optic wand is placed close to the light source so that the light emitted from the light source will be directed into the fiber optic wand. One problem with fiber optic wands is that they are generally unable to capture all of the light that is generated by the light source, particularly light emitted by LEDs, which may be emitted at angles of up to about 120°. Another problem is that fiber optic wands, being essentially solid glass, are relatively heavy and bulky.

[0004] One method for overcoming the limitations of fiber optic wands and for generally improving the lightness and efficiency of the light-curing devices is to place the light

source(s) of the light-curing device at the end of the light-curing device that is placed next to the composition being cured. Although this addressed problems associated with fiber optic wands, the proximity of the light source(s) to the patient's mouth creates its own problems. For example, heat generated by the light source(s) at the tip of the light-curing device can cause patient discomfort when the tip of the light-curing device happens to come in contact or immediate proximity to the sensitive mouth tissues of the patient. Accordingly, it is desirable to minimize the heat at the tip of the light-curing device.

[0005] One method for minimizing the heat at the tip of the light-curing device is to mount the light source(s) on a heat sink that can conduct heat away from the tip of the light-curing device. The ability of a heat sink to diffuse heat is generally controlled by the material properties and geometries of the heat sink. The arrangement and geometries of the mounting surfaces of the heat sink are also important factors to consider when determining how efficiently the heat sink will be able to diffuse heat.

[0006] Recently, light-curing devices have been developed that utilize multiple light sources. One such design incorporates a plurality of LEDs that are mounted on one or more heat sinks. Although a heat sink is incorporated within this design, the bulk of the heat sink mass is located in the vicinity of the LEDs near the patient's mouth. Among other things, the switches and circuitry within the curing light housing prevent extending the heat sink beyond a certain point in the curing light. Thus, a majority of heat is still generated and accumulated near the tip of the curing light that is inserted into the patient's mouth. It would therefore be an improvement in the art to provide improved heat sink configurations to more effectively dissipate heat away from the tip of a dental curing device.

## **BRIEF SUMMARY OF THE PREFERRED EMBODIMENTS**

[0007] The present invention is directed to a dental curing light having a heat sink specifically configured for effectively dissipating heat generated by one or more LEDs away from the tip of the dental curing device.

[0008] According to one embodiment, the dental curing light comprises an elongate hollow wand housing having a proximal first end, a distal second end, at least one LED disposed at the distal second end of the wand housing, electronic circuitry disposed within the wand housing between the first and second ends, and a heat sink within the wand housing.

[0009] The heat sink of this embodiment includes a metallic portion adjacent the one or more LEDs and extending partially through the wand housing, and a thermally conductive polymer-based (*e.g.*, epoxy) portion adjacent to the metallic portion. The thermally conductive polymer-based portion at least partially surrounds the electronic circuitry and extends through a portion of the wand housing that is gripped by the user when in use.

[0010] Forming the heat sink from a metallic portion and a polymer-based portion allows a larger heat sink than would otherwise be possible. The thermally conductive polymer-based portion of the heat sink can be adjacent to the electronic circuitry of the dental curing device without causing electrical conductivity problems (*e.g.*, short circuiting of the circuitry) that a metallic heat sink would cause. Unlike metals, heat-conductive polymer can be injected into the wand cavity at a relatively cool temperature (*e.g.*, room temperature) so as to encapsulate the circuitry without damaging it.

[0011] Because the heat sink can extend through substantially the entire length of the wand, it can efficiently draw heat away from the tip of the dental curing device down towards the portion of the wand gripped by the user. Dissipating the heat away from the tip provides a greater degree of comfort for the patient.

[0012] According to one embodiment, the metallic portion of the heat sink is separated from the wand housing by an air gap. The air gap provides insulation, resulting in less heat diffusing out of the housing wand of the dental curing device in the region around the tip of the curing device, resulting in a cooler tip and greater comfort for the patient. In addition, at least a portion of the heat-conductive polymer portion of the heat sink may directly contact the wand housing in order to selectively cause the wand housing to dissipate heat away from the patient's mouth and toward the part of the wand housing gripped by the dental practitioner. This, in turn, allows the dental practitioner's hand to further draw heat away from the patient's mouth during use.

[0013] The metallic portion of the heat sink may comprise one or more of aluminum, brass, copper, steel, silver or other thermally conductive metal, or a ceramic based on at least one metal oxide. The polymer-based heat sink portion may comprise one or more polymers (*e.g.*, epoxy or silicone) that are sufficiently thermally conductive so as to further conduct heat away from the metallic heat sink portion. The polymer-based heat sink portion may be a solid, liquid, gel or other desired physical state.

[0014] In one embodiment, the polymer or resin is filled with a heat-conductive filler (*e.g.*, carbon fibers, graphite particles, ceramics, and the like) in order to increase the thermal conductivity of the polymer-based heat sink portion. An example of a filled thermally conductive polymer is COOL POLYMER, which comprises a filled polyphenylene sulfide. Virtually any polymer can be made thermally conductive by filling it with a sufficient quantity of a thermally conductive filler.

[0015] In the case where the polymer-based heat sink portion is intended to make direct contact with the electronic circuitry of the curing device, the polymer-based heat sink portion will preferably not contain electrically conductive metals or other materials (at least

on the vicinity of the circuitry) that would cause the polymer-based heat sink portion to short circuit the curing device.

[0016] These and other advantages and features of the present invention will become more fully apparent from the following description and appended claims, or may be learned by the practice of the invention as set forth hereinafter.

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## **BRIEF DESCRIPTION OF THE DRAWINGS**

[0016] To further clarify the above and other advantages and features of the present invention, a more particular description of the invention will be rendered by references to specific embodiments thereof, which are illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

[0017] Figure 1 is a bottom perspective view of a dental curing device according to the invention;

[0018] Figure 2 is an top perspective view of the device of Figure 1;

[0019] Figure 3 is a partial exploded view of the dental curing device of Figures 1 and 2;

[0020] Figure 4 is a cross sectional view of the dental curing device of Figure 1 and 2 taken along cutting line 4-4.

## **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

[0021] A detailed description of the curing device of the invention will now be provided with specific reference to figures illustrating preferred embodiments of the invention. It will be appreciated that like structures will be provided with like reference designations.

[0022] In general, the dental curing light comprises an elongate hollow wand housing having a proximal first end, a distal second end, at least one light source disposed at the distal second end of the wand housing, electronic circuitry disposed within the wand housing between the first and second ends, and a heat sink disposal within the wand housing.

[0023] The heat sink comprises a metallic heat sink portion adjacent the LED that extends partially through the wand housing, and a thermally conductive polymer-based heat sink portion adjacent to the metallic heat sink portion adjacent to, or that at least partially surrounds, the electronic circuitry. The polymer-based heat sink portion extends through the portion of the wand housing that is gripped by the user.

[0024] The term "light source" includes any light source known in the art suitable for use with dental curing lights, examples of which include incandescent lamps, halogen bulbs, light-emitting diodes (LEDs), and LED arrays. The term "LED light source" includes the electrical components of the LED as well as the integral lens or micro lens of the typical LED structure.

[0025] Reference is first made to Figure 1, which is a bottom perspective view of one embodiment of a dental device 100. As shown, the dental device 100 includes an elongate housing 102 that extends between a proximal first end 104 and a distal second end 106. Although the housing 102 is shown to be sleek and slender, it will be appreciated that the housing 102 of the dental device 100 may comprise any desired shape and size.



[0026] A light source 120 disposed at the distal end 106 of the dental device 100 is configured to emit light suitable for curing light-curable compounds, such as, for example, during dental restoration procedures. The light source 120, as shown, includes two LEDs. Although only two LEDs are shown, it will be appreciated that the light source 120 may also include more or less than two LEDs or other light sources. The light source 120 may also include an LED array, a plurality of LED arrays, and any combination of LEDs and LED arrays. The device 100 may also include a lens 140 sized and configured so as to cover the light source 120 at the distal end 106 of the body 102 and to focus light emitted by the light source 120.

[0027] According to one embodiment of the invention, the light source 120 and the distal end 106 of the elongate housing 102 are sized and configured so as to be easily inserted into the mouth of a patient, thereby enabling light generated by the light source 120 to be directly emitted into the patient's mouth without first passing through an elongated light guide (*e.g.*, a fiber optic wand), as required by many conventional light curing devices.

[0028] According to one embodiment, the light source 120 is powered by a remote electrical power supply (not shown), which may include, but is not limited to, the power outlet of a wall receptacle, a battery, a generator, a transformer or any other source capable of supplying power to the dental device. A power cord 122 connected at the proximal end 104 of the dental device 100 operably connects the remote power supply with the dental device 100.

[0029] According to one alternative embodiment (not shown), the proximal end 104 of the dental device is not connected to a power cord 122, but rather the dental device 100 is equipped with an integral battery pack that is capable of powering the dental device 100 and

energizing the light source. The battery pack is advantageously rechargeable (*e.g.*, by direct electrical contact or by induction).

[0030] Figure 2 is a top perspective view of the dental device 100 shown in Figure 1 and further illustrates controls that are disposed on the elongate housing 102 of the dental device 100. According to this embodiment, the controls are configured to enable a dental practitioner to control the activation of the light source 120.

[0031] According to this embodiment, the controls preferably include three different buttons 130, 132, 134. The first button 130, when depressed, selectively activates and deactivates the light source 120. In one embodiment, first button 130, when depressed, may activate the light source for a predetermined duration of time, such as, for example, 15 seconds, thereby enabling the dental practitioner to use the dental device 100 without having to continuously depress button 130 during use. The second and third buttons 132, 134 can be designed to increase or decrease the predetermined duration of time light is emitted by a desired increment of time, such as, for example, by 5 second increments. Alternatively, second and third buttons 132, 134 can be designed to selectively increase or decrease the intensity of light that is emitted. The buttons could alternatively be designed to switch between ramped, pulsed or continuous light output. The curing light 100 may, of course, include any desired number and functionality of buttons or controls.

[0032] The controls are advantageously ergonomically mounted on the elongate housing 102 of the dental device 100 for ease of use. In particular, the controls are advantageously disposed on the body 102 in a manner which enables them to be manipulated by the thumb or finger of the dental practitioner. It will be appreciated, however, that the dental device 100 of the invention is not limited to any particular configuration or type of controls. Rather, the dental devices of the invention may be configured with any type of controls that

are attached to the body of the dental device or that are remotely located away from the device, as desired.

[0033] Figure 3 is a partial exploded view of the dental curing device 100. As can be seen in this exploded view, the elongate housing 102 is hollow so as to allow room for the internal components of the dental device 100. The light source (*e.g.*, LEDs) 120 may be mounted to a metallic heat sink portion 150. In any case, the metallic heat sink portion 150 is configured so as to be adjacent to the light source 120 so as to draw away excess heat produced by the light source 120.

[0034] The metallic heat sink portion 150 may be formed of any suitable metal or thermally conductive metal-based ceramic (*e.g.*, based on one or more metal oxide). Suitable metals include aluminum, brass, copper, steel, or silver. Metallic materials may be used alone or combined into various suitable alloys, as known in the art. Being metallic, the metallic heat sink portion 150 has a relatively high thermal conductivity, effectively drawing heat from the LEDs away from the distal end 106 of the device 100.

[0035] The device 100 also includes electronic circuitry 160 for controlling the operation of the device through buttons 130, 132, and 134 (or alternative controls) as illustrated and described in conjunction with Figure 2. Power may be provided to the electronic circuitry 160 through an electrical connection (not shown) to power cord 122. Additional wiring (not shown) to provide power and control between the electronic circuitry 160 and the LEDs 120 may also be included, as desired.

[0036] In order to provide additional heat sink capacity beyond what is provided by the metallic heat sink portion 150, a thermally conductive polymer-based heat sink portion 152 is located adjacent to the metallic heat sink portion 150. The polymer-based heat sink portion 152 at least partially surrounds, or is adjacent to, the electronic circuitry 160.

Because the polymer-based heat sink portion 152 is thermally conductive, but preferably not electrically conductive, at least that portion that comes into contact with the electronic circuitry 160, it can surround and even touch the electronic circuitry without short circuiting the circuitry 160.

[0037] The polymer-based heat sink portion 152 may comprise one or more polymers (*e.g.*, epoxy or silicone) that are sufficiently thermally conductive so as to further conduct heat away from the metallic heat sink portion 150. In one embodiment, the polymer or resin is filled with a heat-conductive filler (*e.g.*, carbon fibers, graphite particles, ceramics, and the like) in order to increase the thermal conductivity of the polymer-based heat sink portion 152. The polymer-based heat sink portion may be a solid, liquid, gel or other desired physical state.

[0038] In the case where the polymer-based heat sink portion 152 is intended to make direct contact with the electronic circuitry of the curing device, the polymer-based heat sink portion 152 will preferably not contain electrically conductive metals or other materials (at least on the vicinity of the circuitry) that would cause the polymer-based heat sink portion 152 to short circuit the curing device. The polymer-based heat sink portion 152 may include electrically conductive metals or ceramics so long as it does not directly contact exposed electronic circuitry 160 (*i.e.*, there is any insulating material or gap between the polymer-based heat sink portion 152 and the electronic circuitry 160).

[0039] Because of the relatively large surface area of the two heat sink portions 150 and 152, the metallic heat sink portion 150 and polymer-based heat sink portion 152 together draw heat away from the distal end of the device 100 more effectively than a metallic heat sink of smaller size by itself.

[0040] As illustrated in the cross sectional view of Figure 4, there may be a heat-insulating layer 170 between the metallic heat sink portion 150 and the elongate housing 102. According to one embodiment, the heat-insulating layer 170 may be an air gap, although it could alternatively be filled with any known heat-insulating material (*e.g.*, insulating ceramics or polymers). Providing a heat-insulating layer 170 surrounding the metallic heat sink portion 152 reduces the amount of heat that would otherwise be dissipated out of the distal end of the device 100. Reducing dissipation of heat at the distal end 106 of the curing light 100, which is nearest the patient's teeth, mouth, and other sensitive tissue, results in a more comfortable operation.

[0041] In one embodiment, there is no thermally insulating layer between the polymer-based heat sink portion 152 and the housing 102. This increases the amount of heat dissipation that is in the region of the housing 102 that is away from the patient's mouth. Channeling the heat so that it is dissipated away from the patient's mouth results in a more comfortable operation for the patient, as described above. Moreover, more efficiently dissipating heat when the housing 102 is gripped by the dental practitioner can act to further withdraw heat away from the patient's mouth by instead directing it toward the user's hand.

[0042] The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed is:

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